SCIENCE

FRIDAY, JULY 1, 1910

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

PHYSICS AND EDUCATION

AT the recent meeting of the American Association for the Advancement of Science a joint session of Sections B, Physics, and L, Education, was devoted to a discussion of the teaching of physics. This is the first time in the history of the association that such a discussion has formed part of the regular program. It indicates the change that is slowly but surely creeping over the university mind of the country in that the problems of teaching are coming to be regarded as research problems of at least no less importance and difficulty than those of pure science. Section L, to be sure, devotes all its sessions to the presentation and discussion of research work in education; but it is encouraging to have Section B also turn its attention in this direction.

Those who attended this joint session have been impressed with the wide difference in the points of view from which the two sections surveyed the field. It is a familiar fact that specialists in any field are very wary about committing themselves definitely in reply to questions about their specialty. Ask a geologist what a specimen of rock is, and he will reply that it looks like limestone, and probably is that, but he would not care to be quoted as having said that it was limestone until he had made suitable tests and verified the statement carefully. The same geologist does not hesitate to give final decisions on matters of politics or even of education, although he has never studied either scientifically. He would even be ready to legislate about the re-

quirements that high schools must meet, although he has never seen the inside of a high school since he himself graduated. Yet he would legislate on the basis of vague impressions retained from his own school days and other vague impressions he has received from others. A very similar condition prevails with the two sections. Section B criticizes any new suggestion in physical science very searchingly, submits it to rigorous, unbiased tests and insists on satisfactory verification. Section L does the same in the field of education, but takes its physics largely on faith and with little attempt at criticism or verification. Section B treats suggestions in education as Section L does those in physics; but with this difference —L does not presume to dogmatize about physical science.

This fundamental difference in the attitudes of the two sections leads to a radical difference in their respective attitudes toward physics teaching. This difference was pointed out most lucidly by Professor Dewey in his vice-presidential address on "Science as Method and as Information." This difference is not sharply defined in that all members of B do not regard the imparting of information as the sole end of science instruction any more than all the members of L regard the acquirement of the scientific method of thinking as the sole aim of teaching. There is, however, a marked difference in the ways in which the two sections place the emphasis. For B, information is paramount and method of thinking subordinate; for L, the reverse is true.

From this prime difference between the two sections follow a number of subsidiary differences. These may be paired off in couples in some such way as that given below. It is, of course, not possible that the characteristics of the members of a pair be intrinsically and mutually exclusive. Nor is it claimed that Section B stands wholly and solely for the first set, and Section L wholly and solely for the second. It is again a matter of emphasis. Section B as a whole strongly emphasizes the elements in the first set; while L, in like manner, strongly emphasizes those in the second.

B	L
1. Logical arrangement of concepts.	Intuitive development of concepts.
2. Analytical reasoning with abstract ideas.	Good judgment in concrete cases.
3. Forestalling possible future needs of physicists.	Meeting actual present needs of students.
4. Power to pass possible examinations.	Power to act intelligently in actual situations.
5. Learning laws intellectually.	Power to solve problems scientifically.
6. Verbal statements of principles.	Weighing of evidence.
7. Intellectual attainment.	Social efficiency.
8. Satisfaction of college requirements for few.	Service to community for all.
9. Mental discipline.	Enthusiasm and motive.
10. Logical rigor.	Useful approximation.

Up to the present time the first set of characteristics have been dominant in physics teaching. It is for this reason that this teaching has not been satisfactory. The present problem is, not to make the other set as overbearing as the first has been, but to get a just balance between them. It is not that logical arrangement should be banished and intuitive development substituted; but that intuitive development should precede and lead up eventually to logical order. It is not that social efficiency precludes intellectual attainment; but that social efficiency should precede

in importance. The other will surely follow. The reverse is, however, not true—a man may have high intellectual attainments and be socially highly inefficient.

Again, it has been forcibly proved of late that when a high school tries seriously to meet college requirements, it fails egregiously in service to its community. On the contrary, when it serves its community efficiently, it should meet college requirements far better than at present. In like manner, mental discipline may be possible without enthusiasm and motive, but at best it trains the intellect only while the will runs riot with morality. But when enthusiasm and right motive precede, not only is the mind disciplined, but the will also, leading to firm character as well as intellectual strength.

But perhaps the difference between the two points of view is most forcefully shown in the respective attitudes of the two sections with regard to the use of physics for entrance to college. Section B has, as a whole, always regarded high-school physics as being taught mainly for purposes of college entrance. In this subject, more than in any other, the high schools have been "required" to try to teach what the colleges specified was "the thing." These specifications have always been framed by college men with a view to forestalling the needs of physicists and to securing a treatment of topics that should be the most logical and rigorous known in the then state of the sciences. College men have criticized elementary texts as if they were scientific treatises instead of tools for education and have denounced educationally insignificant departures from current scientific creed as illogical or unscientific. High-school men have never been encouraged to try experiments in teaching, in an endeavor to find out by experiment—the only possible way—what is best for high school pupils. And why should they try experiments when those who were masters of *physics* had said that the *teaching* must conform to these definitions?

Section L, on the other hand, can not accept the postulate that the straight and narrow path laid out by the colleges is the best way to teach elementary physics without scrutinizing closely the results of the work; any more than Section B will swallow Blondlot N rays without inspecting them carefully. Nor do we have to look far for conclusive evidence. Most of us find it in the examination books turned in by our students at every examination. As physics teachers we are amused at the "new knowledge" and utter nonsense contained in these books. We are so used to it that we have ceased to regard it as indicative of a serious condition. We laugh it off with the remark: "Every exam brings out samples like that." "And after all," argue the physicists, "what harm is done? The great majority of the pupils will not have to know how to calculate the velocity of a body sliding down a plane, nor will they be seriously handicapped in life if they do not know what the index of refraction is. If they do not know a thing, they should be taught to say they do not know instead of making up such nonsensical answers." In like manner we comfort ourselves for failures to make clear other portions of the subject, all leading to the very obvious question: Why attempt at all to teach such things under the name of physics that when a boy is questioned about them the only sensible answer he can give is "I don't know?" Perhaps some other member of Section B will answer this.

Another important test of results is given annually by the College Entrance Examination Board. The result is that out of fourteen questions set, about

seventy per cent. of the candidates fail to answer four correctly. Perhaps some of the colleges that examine entering students in physics can furnish more encouraging figures on this matter. So Section L is prone to conclude that the method prescribed by the colleges is failing to meet the expectations of the colleges as manifested in their examinations. Either the method or the examinations or both must be a misfit.

Even Section B is now half persuaded that this is so. But the blame is laid on the poor teacher who has been working his best to do faithfully what he was told to do and not on the college-born and bred specifications of the course nor on the examinations. As a cure it is urged that we need better prepared teachers, better laboratory facilities, better apparatus, and an attendant who is mechanically inclined, so that the teacher may have more leisure. We are told that physics teachers should have taken an M.A. in *physics,* should know some calculus and some chemistry: but not a word is said about knowing boys, understanding schools and having some idea of what a problem in education looks like and of how to go about to solve it—in a word, about having better *teachers.*

Section L agrees to the desirability of all the good things suggested by its colleagues B. But it is very certain that the trouble does not lie so much with the teacher and his apparatus as it does with the sort of a thing he is told to do, and the way in which the specifications were made and are administered. This conclusion is based on the fact that the course has been designed after a study of logical order, scientific rigor and the possible needs of physicists, and not after a scientific study of high school pupils and their needs and mental possibilities. No such study of pupils has, so far as I know, been made in America, excepting by President G. Stanley Hall; and, although everybody knows what his conclusions are, they have not yet received the attention that is due them. In a few cases President Hall's suggestions have been put into practise with great success, but the colleges have refused to give entrance credit for this most creditable work, thereby discouraging all but the bravest teachers from trying it.

Under the conditions that exist in the country to-day, the suggestion that better apparatus and teachers who know more *physics* are needed does not begin to solve the problem. The statistics of the bureau of education show that there are in the country in towns having more than 8,000 inhabitants but 800 high schools. These schools average 17 teachers each, and have 365,000 pupils. In the smaller towns there are 8,160 high schools having an average of 2.7 teachers each and 405,000 pupils in all. Therefore 53 per cent. of the pupils attend small high schools which have less than 6 teachers each. In such schools the man who teaches physics must also teach two or three other subjects. Therefore he must be a *teacher* rather than a *physicist.* Not more than one in ten of those who teach physics can be expected to have an extended knowledge of the subject.

In 1908 there were 29,000 high school graduates who were prepared for college. The number of those who study physics each year in the high schools is about 130,000. Not all who were prepared for college had studied physics. It is safe to say that not more than one in every five of those who studied physics used it for college entrance. Therefore the problem is not how shall we produce conditions in which the present quasi-rigorological *physics* shall be taught everywhere by specialists, in preparation for a profession that almost none follow; but rather how, under

existing conditions, we shall get for all who study it the best possible *teaching* of physics in the brief time allotted to this subject. This is not an easy problem, since it involves the reorganization of a large body of subject matter on a new basis—instead of being a logical system, it must be a teachable system. The emphasis must be shifted, so that it falls less heavily on the traits assigned above to Section B and more heavily on those ascribed to Section L.

The solution of this problem will take a long time and require much experimenting and much scientific study. It involves a careful study of how we obtain clear notions of physical principles—what part do our motor reactions and what part does our reason play in this process? We certainly do not come to understand a subject like acceleration by learning definitions and formulæ and solving never so many unreal numerical problems. In Germany much attention has been given recently to the experimental solution of this problem by Frey, Seyfert, Verworn, Remus[1] and others, not to mention their celebrated Unterrichtskommission. But in America nothing has as yet been done in this direction. America showed Germany the necessity of having laboratories for high schools; must we learn from her how to use them for the best educational results? Are we not competent to study this problem on our own account, and to solve it for ourselves in a way that will suit our own peculiar conditions?

Therefore, the partnership that has been started between B and L is an auspicious event, because both are parts of a scientific organization where all problems are solved in a scientific way. Certain it is that as suggestions for change are tried out in practise, as hypotheses are tested and submitted to scientific scrutiny and criticism, and as educational theories are verified by experiment, the points of view of the two sections will gradually approach each other. Who knows but that they may some day coincide?

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[1] Frey, O., "Arbeits unterricht," Leipzig, Wunderlich, 1907. Seyfert, R., "Die Arbeitskunde," Leipzig, 1902. Verworn, M., "Beiträge zur Frage des naturwissenschäftlichen Unterrichts an den höheren Schulen," Leipzig, Teubner, 1906. Remus, K., "Der Dynamologische Lehrgang," Leipzig, Teubner, 1906.

PROFESSORIAL ETHICS

WHEN I was at a university as an undergraduate—I will not say how many years ago—I received one morning a visit from a friend who was an upper classman; for, as I remember it, I was a freshman at the time. My friend brought a petition and wished to interest me in the case of a tutor or assistant professor, a great favorite with the college boys, who was about to be summarily dismissed. There were, to be sure, vague charges against him of incompetence and insubordination; but of the basis of these charges his partizans knew little. They only felt that one of the bright spots in undergraduate life surrounded this same tutor; they liked him and they valued his teaching. I remember no more about this episode, nor do I even remember whether I signed the petition or not. The only thing I very clearly recall is the outcome: the tutor was dismissed.

Twice or thrice again during my undergraduate life did the same thing happen —a flurry among the students, a remonstrance much too late, against a deed of apparent injustice, a cry in the night, and then silence. Now had I known more about the world I should have understood that these nocturnal disturbances were signs of the times, that what we had heard in all these cases was the operation of the